Cost−effective single board PDP sustaining driver with dual resonant method

Hyun−Muk Lim, Cheol−Hwan Eom, Jun−Young Lee

Department of Electronics Engineering., Dankook University
Anseo−Dong, Cheonan−Si, Chungnam, 330−714, Republic of korea

ABSTRACT

A new plasma display panel sustaining driver using single side sustaining technique with the dual resonant method is proposed. Since this circuit enables to reduce switches in energy recovery circuit with keeping voltage stress like that of prior circuit, it can be low cost circuit comparing with a conventional driver. To integrate sustain function into one side with single power source in the driver, a charge pump method is adopted to make negative sustaining voltage and achieve dual resonant energy recovery on sustaining modes.

1. Introduction

Digital broadcasting and the infrastructure of digital net−works represented by the Internet is progressing quickly in many nations.[1] Moreover, many consumers are turning to a wide digital TV to equip their home theater systems. To meet these requirements, many kinds of digital displays have been developed and plasma display panel (PDP) has advantages over other flat panel displays (FPDs) such as the wider view angle, larger screen, higher brightness, and thinness. Thanks to these advantages PDP is expected to widen its market share in the digital digital display market.[2] Thus, to attract many consumers, the development of a low−cost driving technology for PDP is required. The operation of PDP is divided into three periods: reset, addressing, and sustaining. The sustaining operation of PDP has been performed by applying sustain pulses to X,Y electrodes alternately. If the two sustain pulses are merged to one sustain pulse with both the positive and negative voltage levels[3],cost of PDP can be decreased because energy recovery and sustain switches are reduced. However, this method has a defect that is double voltage stress in these switches[4], so high voltage switching devices are required which contributes to an increase of PDP cost.

In this paper, a low−cost sustaining driver integrated sustain function into one side is proposed. Although sustain switch blocks a few increase, this driver is able to maintain voltage stress same as a conventional driver despite reduction of energy recovery switch by using dual resonant energy recovery technique. In addition, charge pump concept is adopted to achieve not only dual resonant energy recovery but also decrease of voltage stress in sustain switches by using single power source.

2. Proposed driver

2.1 Circuit description

Fig. 1 shows the proposed PDP driver adopting the dual resonant method. Since the dielectric layer of MgO is encrusted on sustaining(X) and scanning(Y) electrodes, capacitance between two electrodes exists inherently. This is modeled by C_p. The Y sustaining driver is composed of two switching blocks, respectively. Y_s, Y_h are for applying positive sustaining voltage pulse to Y electrode and negative sustaining voltage pulse is applied by Y_g, Y_L to same electrode. Capacitor C_1 charged to V_s while the electrode is maintained at V_s level has functions of applying the negative sustaining voltage and realizing the dual resonant energy recovery by switching operation of Y_s, Y_g...

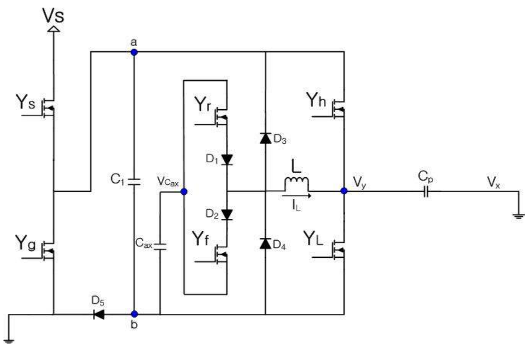

Fig. 1. Proposed single board PDP sustaining driver

2.2 Operational principles

The operation can be divided into three modes and mode analysis is performed about the first half cycle because the operation of the two half cycles is symmetric. It is assumed that before the start of mode 1, the switches, Y_g, Y_L are turned on. In addition, C_1 and C_{ax} are charged to V_s and $1/2V_s$, respectively.

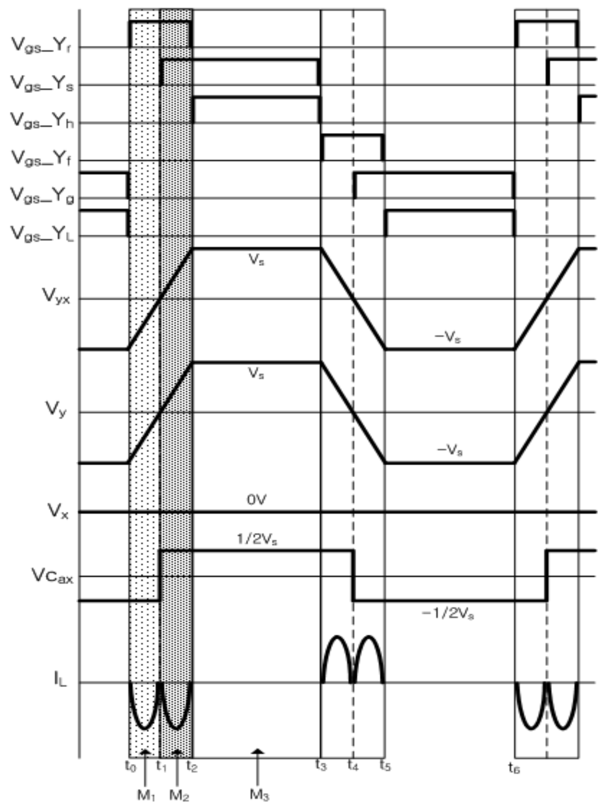

Fig. 2. Operational waveform of proposed driver

Mode 1 ($t_0 \le t < t_1$)

Mode 1 begins at t_0 when Y_L is turned off and Yr is turned on. Current path is formed including Y_g, C_1, C_{ax}, and Yr, L at Y electrode. Accordingly, a resonance is occurred between L and C_p to recover energy of panel until V_y become GND level. During this mode, potential of point b at C_1 is kept on $-V_s$ potential since point a of C_1 is connected with GND by Y_g it has been turned on, so D_5 is blocked and Vc_{ax} becomes $-1/2V_s$. Moreover, it can generate negative sustaining voltage without external power source. Referring to Fig. 3, the drain-source voltage of Y_f which does not conduct is $1/2V_s$. In this mode, a voltage recovered from C_p and current that flows to C_p can be expressed as follows :

$$V_{yx} = (-\frac{V_s}{2} - V_{D1})\,[1 - e^{-\frac{t}{\tau}}(\cos\omega t + \frac{R}{\omega L} sin\,\omega t)] \quad (1)$$

$$Ic_p = \frac{1}{L\omega}(-\frac{V_s}{2} - V_{D1})e^{-\frac{t}{\tau}}\sin\omega t \quad (2)$$

where $\tau = (2L/R)$ and $\omega = \sqrt{(1/LC_p) - (R/2L)^2}$

(R : equivalent series resistance on energy recovery path)
(V_{D1}: on drop voltage of the diode)

Mode 2 ($t_1 \le t < t_2$)

When Y_g is turned off and Y_s is turned on, mode 2 begins at t_1. At this time, the point b of C_1 rises from $-V_s$ to GND, so VC_{ax} is varied from $-1/2V_s$ to $1/2V_s$ because Y_s, D_5 are turned on respectively. Therefore, the resonance is took place once more until V_y becomes V_s level with maintaining the voltage of Y_f as $1/2V_s$ equal to previous mode. For that reason, the dual resonant energy recovery can be accomplished, which keeps voltage stress of energy recovery switch same as conventional driver. In this mode, likewise mode 1, the parameters can be expressed as follows :

$$V_{yx} = (\frac{V_s}{2} - V_{D1})\,[1 - e^{-\frac{t}{\tau}}(\cos\omega t + \frac{R}{\omega L} sin\,\omega t)] \quad (3)$$

$$Ic_p = \frac{1}{L\omega}(\frac{V_s}{2} - V_{D1})e^{-\frac{t}{\tau}}\sin\omega t \quad (4)$$

Mode 3 ($t_2 \le t < t_3$)

At the mode 3, Y_r is turned off and Y_h is turned on, so sustain pulse is applied to C_p with charging C1 to perform charge-pump operation.

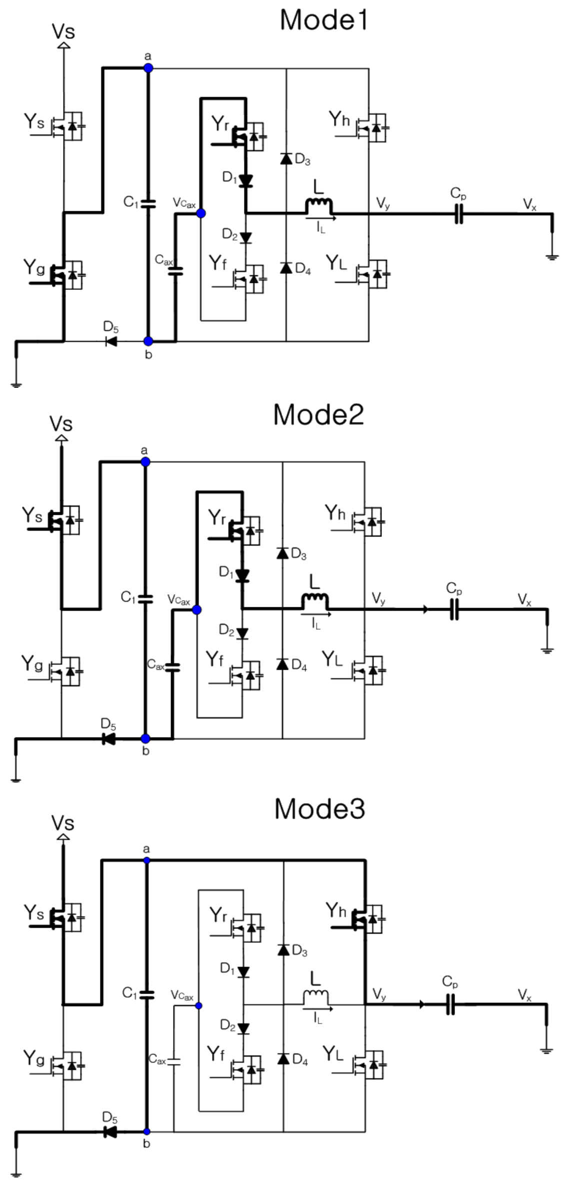

Fig. 3. Current path of each mode in proposed driver

3. Experimental results

A experiment was performed about proposed driver to prove usefulness of that by applying to 42inch panel, and the waveform is shown to the Fig4 as a result of the experiment. The Fig4 is magnified waveform of sustain field, and it shows Y electrode voltage(V_y), resonant current of inductor(I_L), auxiliary capacitor voltage(Vc_{ax}). Sustain voltage was applied by 180V to discharge the panel completely. While V_y is changed between V_s and $-V_s$,I_L that is resonant current between L and panel capacitance(C_p) occurs twice according to invert Vc_{ax}, the first current takes place while V_y rises from $-V_s$ to 0V like the mode 1 and second current occurs while V_y rises from 0V to V_s like the mode 2 in the Fig 2. In this period, Vc_{ax} is always keeping a half voltage level of sustain voltage, so voltage stress of energy recovery switches can be maintained as $1/2V_s$. Besides, according to this waveform, we can find that the peak point of second resonance current is higher than that of first resonance current, it is based on a length of the second resonance path longer than the first resonance path on real driving board, and it effects resonant frequency by changing inductance value on the path. For that reason, such a waveform can be appeared. Fig5. is undischarged waveform, so displacement current only exists in the panel. We can find that the dual resonant operation is occurred in any condition from these waveforms.

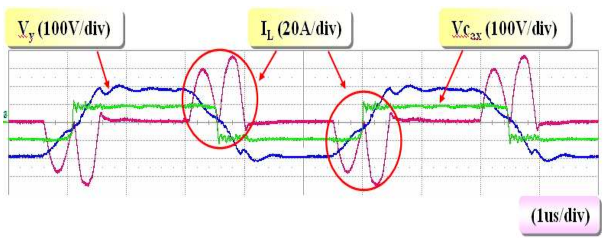

Fig. 4. Waveform of dual resonance with discharge

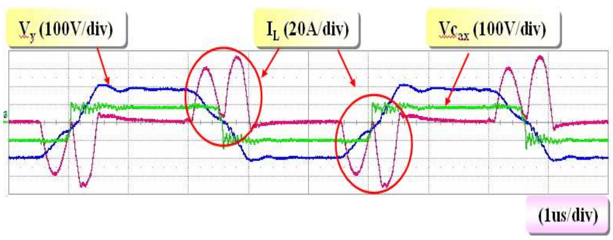

Fig. 5. Waveform of dual resonance without discharge

4. Conclusions

In this paper, single board PDP sustaining circuit applied dual resonant method is proposed, and the circuit is verified through driving experiment to actual 42 inch PDP panel. To realize single side sustaining circuit without increase of voltage stress, dual resonant energy recovery concept using charge pump method is adopted. Accordingly, this circuit has so important merit that can maintain voltage stress of energy recovery switch same as that of conventional circuit though the switch is reduced. To understand the voltage stress objectively, we compared that with single resonant method which performs energy recovery through just once resonance, and it is realized by replacing auxiliary capacitor to GND in the proposed circuit.. In the table 1, we can find that the voltage stresses of Y_r and Y_f are half of single resonant method.

Table 1.Comparing voltage stress with single resonant method

	Dual resonant	Single resonant
Y_s	Vs	Vs
Y_g	Vs	Vs
Y_h	Vs	Vs
Y_L	Vs	Vs
Y_r	**Vs/2**	**Vs**
Y_f	**Vs/2**	**Vs**

In addition, despite increase of sustain switch count above simple single sustaining driver, by applying charge pump concept this circuit enables single power source to be usable and to reduce voltage stress of sustain switches. Therefore, the proposed driver is expected to be suitable for a low-cost PDP sustaining driver.

This work was supported through research fund by LG Electronics, Republic of korea.

참 고 문 헌

[1] Jun-Young Lee, "Picture-Based Address Power Saving Method for High Resolution Plasma Display Panel(PDP)", IEEE Trans. Ind. Electron., Vol. 55, No. 1, pp. 49-58, Jan. 2008

[2] Jun-Young Lee, "Cost-effective PDP sustaining driver with current injection method", Electron. Lett., Vol. 38 pp. 1637-1638, December 2002.

[3] Byung-Gwon Cho and Heung-Sik Tae, " A Study on Wall-Charge Behavior of Single-Sustain Waveform Based on V_t Close-Curve Analysis in AC Plasma Display Panel ", IEEE Trans. Ind. Plasma Science, Vol. 36, No. 1, pp. 192-199, February 2008.

[4] Ki-Bum Park, Seong-Wook Choi, Chong-Eun Kim, Gun-Woo Moon, and Myung-Joong Youn, " New Single Sustaining Driver for AC-PDP employing Voltage Stress Reduction Technique ", 1-4244-0655-2/07/2007 IEEE, pp. 2223-2226.